Armed Forces College of Medicine

AFCM

Blood

White Blood Cells (Leukocytes)

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Intended Learning Objectives (ILO

By the end of this lecture the student should be able to:

- **Correlate** the structure of WBCs to its function
- **Interpret** the defective structure of the WBCs in different diseases

Lecture Plan

1. Part 1 (3 min) Introduction to white blood cells
2. Part 2 (40 min) white blood cells structure and function
3. Part 3 (3 min) Summary
4. Lecture Quiz (4 min)

Blood

- = A special type of connective tissue in which the matrix is fluid (plasma).
- Average volume in adult : 5 liters
- Origin: mesenchyme

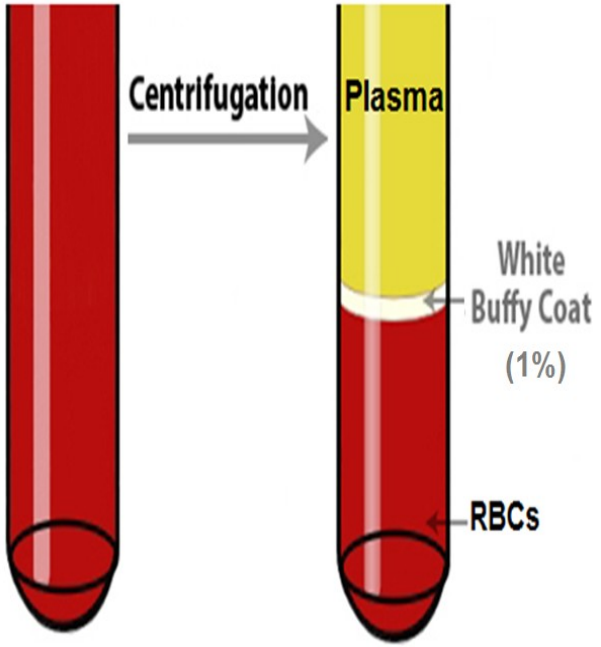
Components of blood

Plasma

1- Water (92% of plasma)
2- Proteins
3- Others:
(Electrolytes, Nutrients, Respiratory gases, Waste

Blood elements 45%

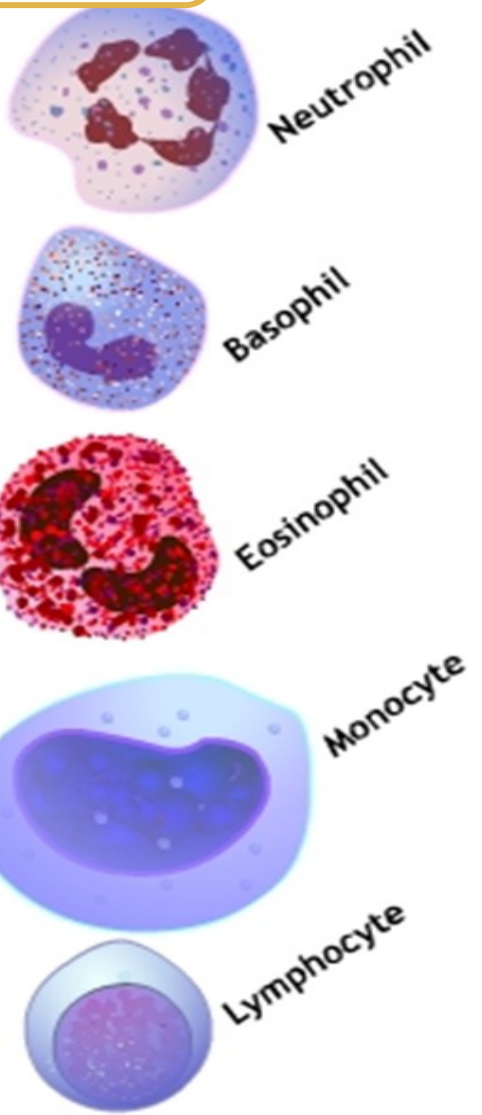
1- Red blood corpuscles (RBCs) = Erythrocytes
2- White blood cells (WBCs) = Leucocytes



Leukocytes (White Blood Cells)

- **4500-11,000 /mm3 (µL)**
- **Colorless in fresh conditions / white if packed.**
- **True cells having nuclei and organelles.**
- **Spherical while suspended in blood plasma, but they become amoeboid and motile after**

o perform various activities related to immunity

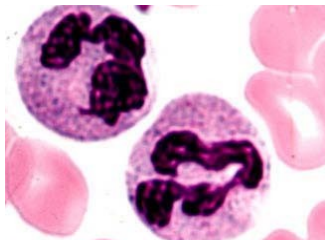
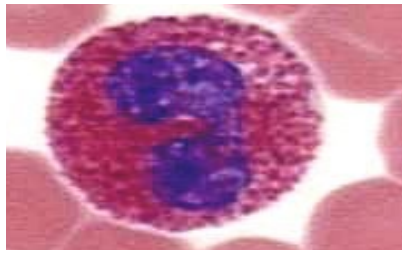
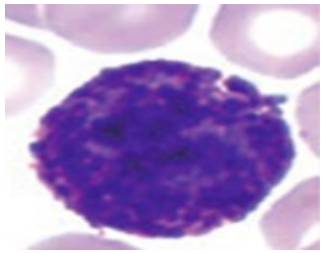


Leukocytes (White Blood Cells)

Granulocytes

- 2 major types of granules (specific & non-specific granules)
- Life span of only a few days.

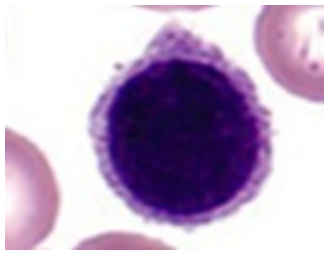
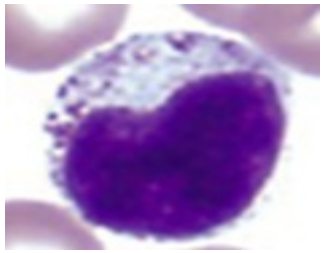
Neutrophils **Eosinophils** **Basophils**

Agranulocytes

- Lack specific granules but contain non-specific azurophilic granules.
- Life span: up years

Lymphocytes **Monocytes**

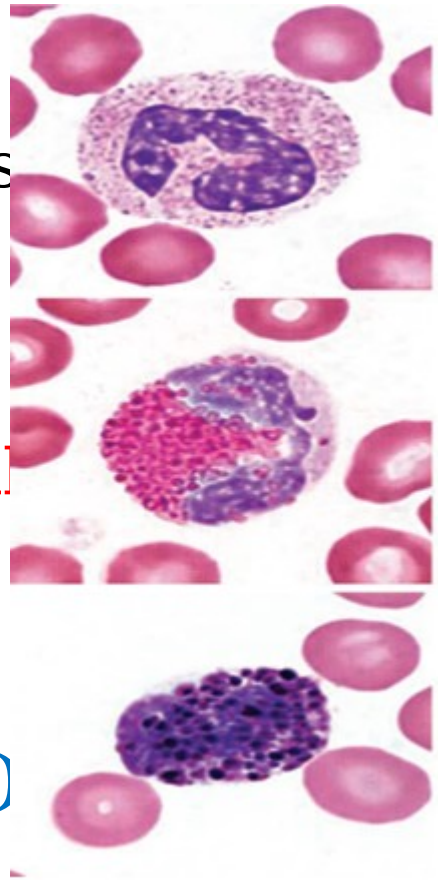
2 Major types of granules:

1.Specific granules:

Neutral (neutrophils

Acidic (eosinophi

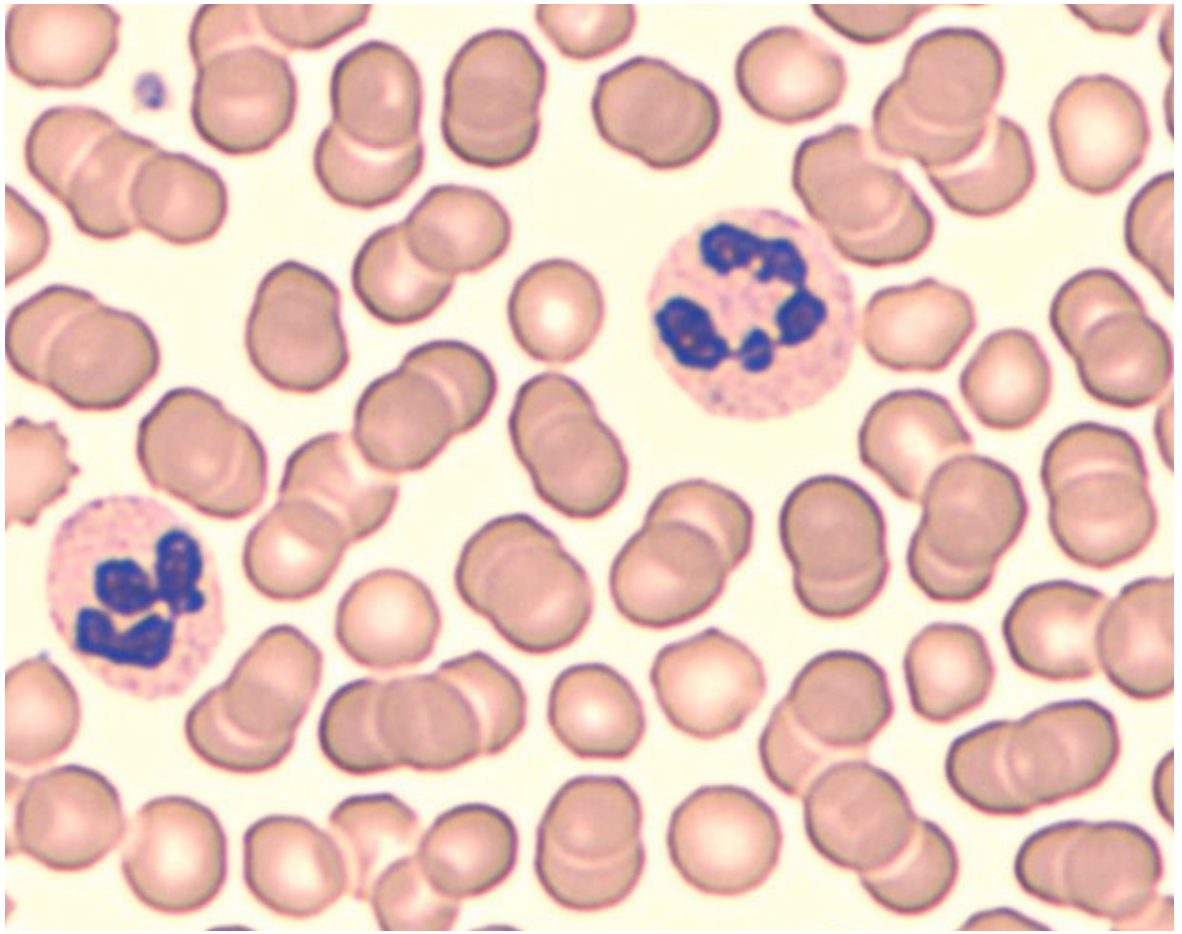
Basic (basophils)



2. Non-specific (Azurophilic) granules

- **=Lysosomes**
- Affinity for **methyl azure stain (blue-purple)**
- Present in **all leucocytes.**

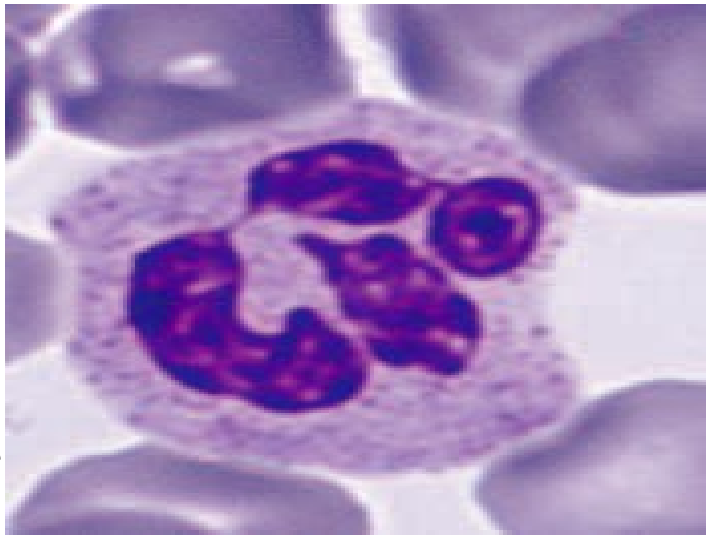
Neutrophils



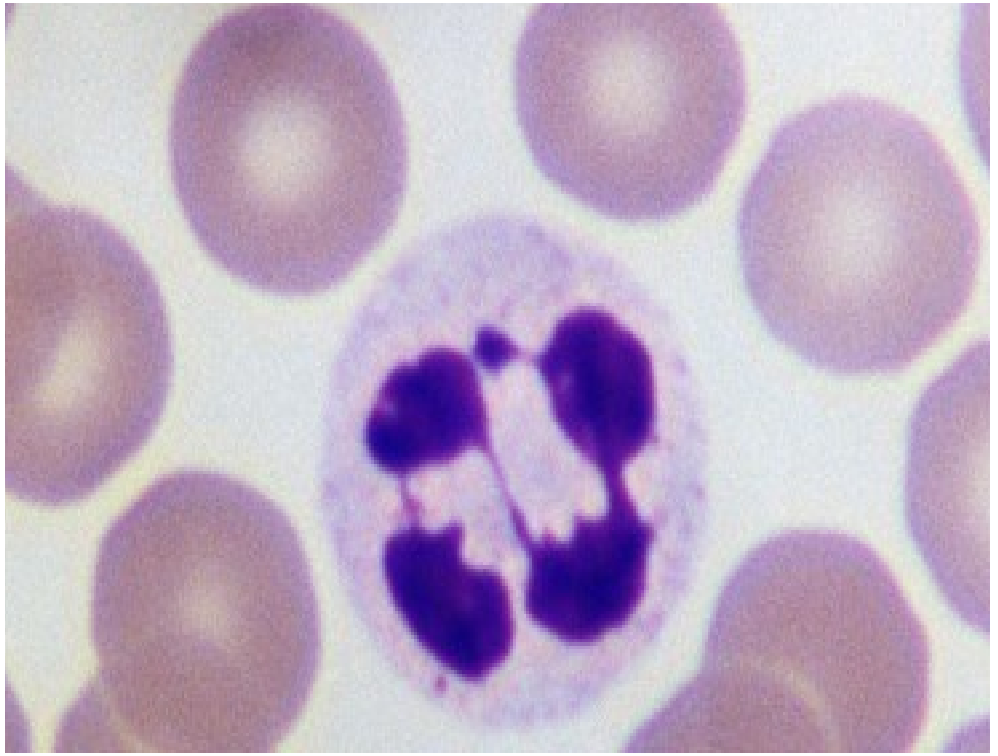
http://medcell.med.yale.edu/histology/blood_bone_marrow_lab/neutrophil.php

Neutrophils

Number:	**60-70%**
Size:	**12-15 µm in diameter**
Life span:	**hort –lived cells (6-8hr)**
L.M.:	**N:** segmented deeply stained multi-lobe (2-5) interconnected by delicate chromatin strands. (polymorph nuclear leucocytes =



"Band neutrophil": immature neutrophil with horse shoe shape-like nucleus (< 1-2% in a blood film)



Barr body

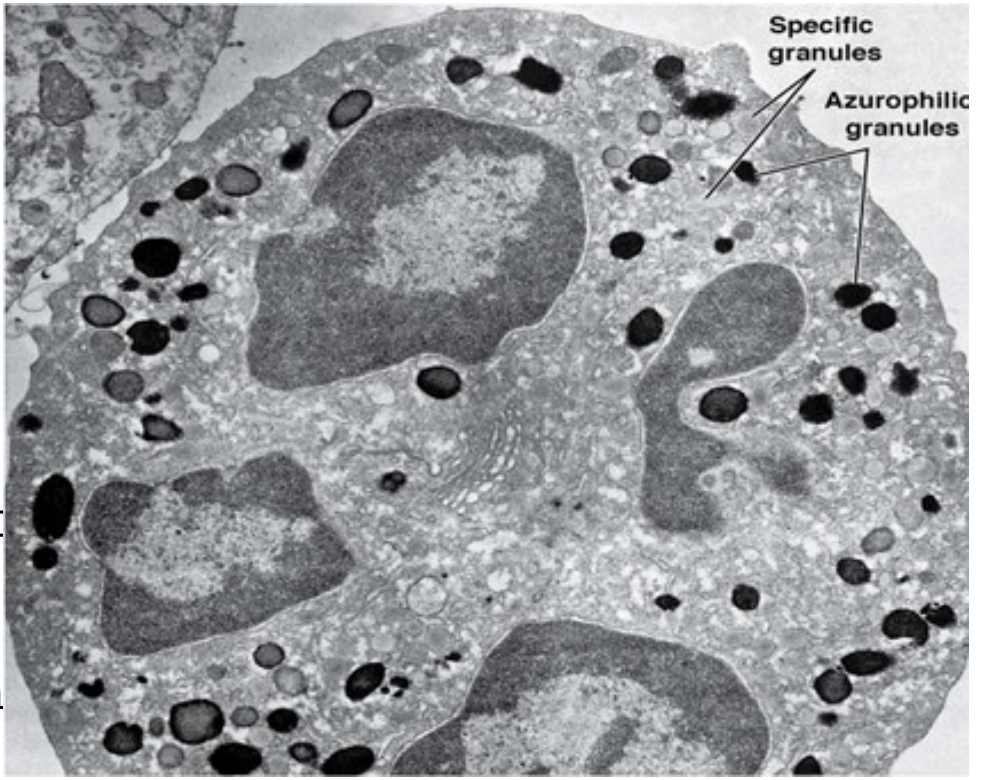
= Drumstick-like appendage on one of the lobes of the nucleus

In 3% of neutrophils in peripheral blood films of

E.M.:

N: highly condensed chromatin

C: glycogen, small rER, Golgi, few mitochondria



3 Types of granules:

1- 1ry Azurophilic granules:

- **larger** (0.5 µm) / rounded / **more electro dense**
= **primary lysosomes**
- Secrete **myeloperoxidase, lysozym**

2- Specific granules:

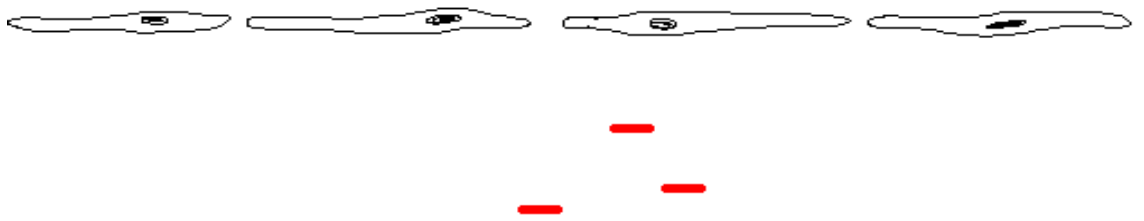
- **Smaller / less electron dense**
- **More numerous**
- Secrete **ECM degrading enzymes as collagenase, bactericidal zymes.**

3- Tertiary granules :

- **Contain metalloproteinase as gelatinase to help migration of neutrophils through the CT.**

Function:

- **Phagocytosis** of foreign organisms and destruction of bacteria
- Neutrophils are inactive and spherical while circulating but **at areas of infection, neutrophils are first to arrive** (become amoeboid and leave the blood vessel by diapedesis) and become active and pursue the bacteria by chemotaxis.
- Neutrophils **die** after MARGINATION rmation.



Pus:

is accumulation of dead leucocytes, bacteria & extracellular fluid)

Abnormal Neutrophil count

- **Neutrophilia (+++):**

  Occur in bacterial infect

"Shift to the left"

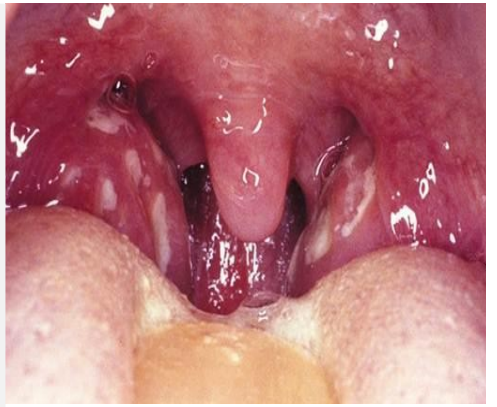
++ percentage of band neutrophils

- **Neutropenia (- - -):**

  Results in liability to bacterial infection

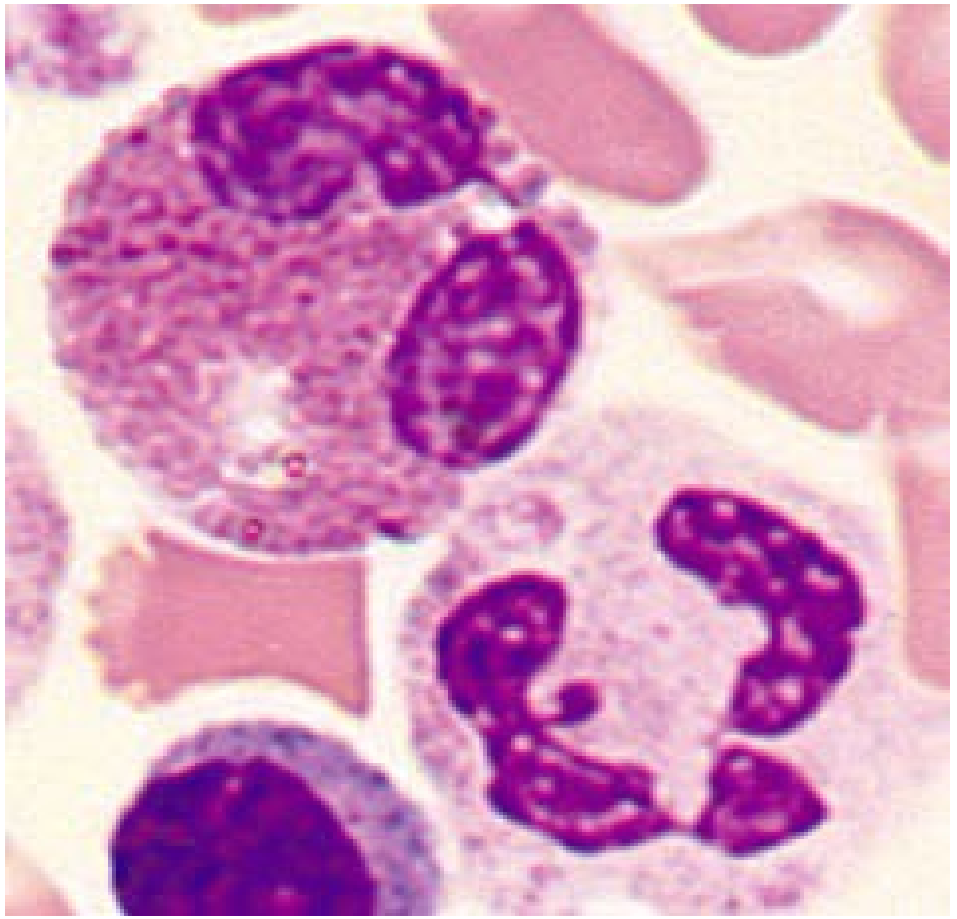
A 6 years old boy complained of dysphagia. His tonsils were red with white spots. Doctor asked for CBC. What do you expect?

Neutrophilia



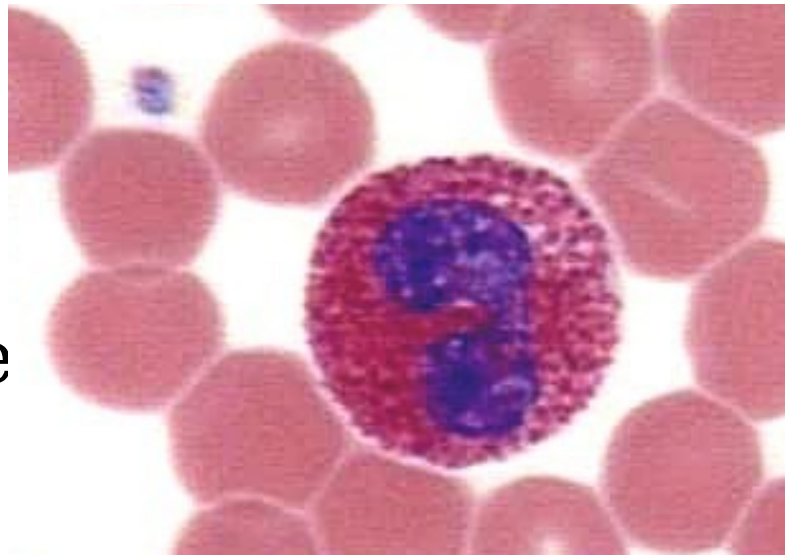
https://www.researchgate.net/publication/315349776_Differential_diagnosis_of_tonsillitis_tonsillar_detritus_accumulation_and_tonsillar_keratin_cysts/figures?lo=1&utm_source=google&utm_medium=organic

Eosinophil



Eosinophil

Number	**1-4% of total leucocytic count**
Size:	**12-15 µm in diameter**
Life	**8-10 days**
L.M.:	**N:** **bilobed**, less densely staine than that of neutrophils **C:** large retractile **acidophilic** granules

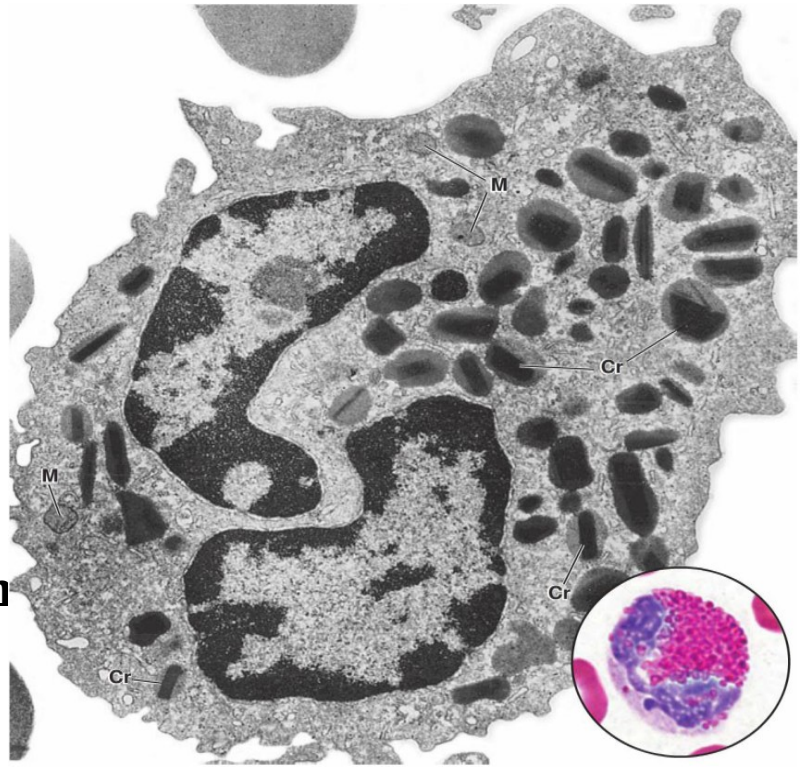


E.M.:

N: highly condensed chromatin

C: small rER, Golgi, few mitochondria

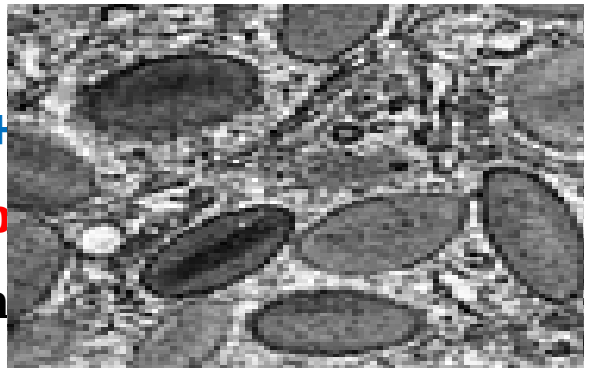
2 Types of granules:



1- 1ry Azurophilic granules: Non-specific **prim**
lysosomes

2- Specific granules:

- **large oval**
- **Have electron dense crystalloid core "internum" surrounded by a less electron dense matrix" externum"**
- **The crystalloid core = major basic protein +peroxidase+**
  (Major basic protein accounts for their acidophilic app
- **The externum = large amount of arylsulfatase, histamin**



- **Major basic protein, peroxidases and neurotoxins are cytotoxic to parasites**

https://gfycat.com/informalgoldenkudu

Functions:

- **Phagocytosis of antigen-antibody complexes**
- **Secrete histaminases (inactivates histamine produced by mast cells).**
- **Discharge their granules contents of on the surface of parasitic worms killing them**

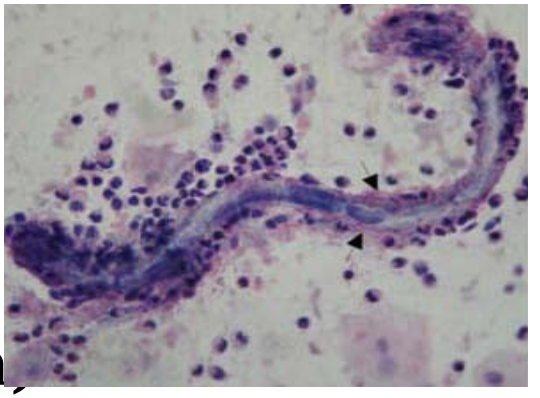
Anti-allergic & Anti-parasitic

Abnormal Eosinophil count

- **Esinophilia (+++):**

  Parasitic infection (Ex: bilharziasis)

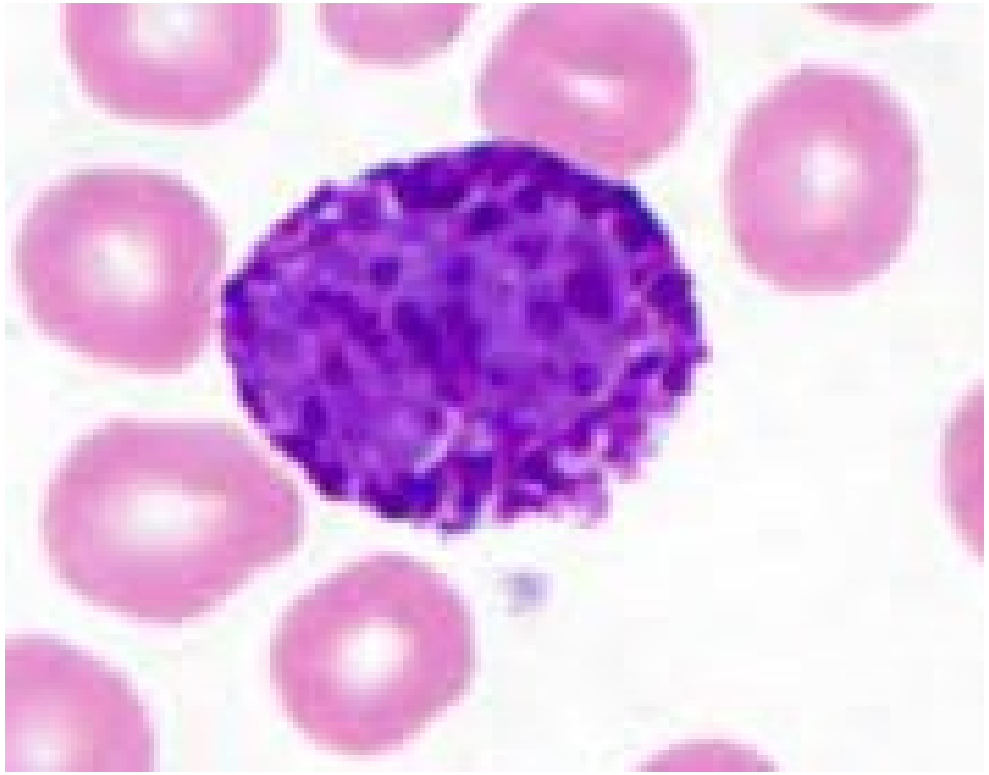
  Allergy (ex., asthma, urticaria and eczema)



- **Esinopenia (- - -): Corticosteroids**

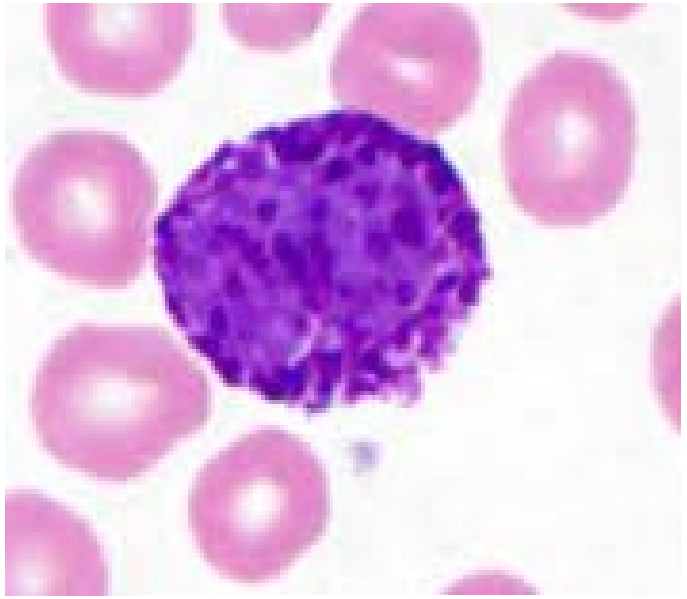
https://www.zazzle.com/eosinophil+tshirts

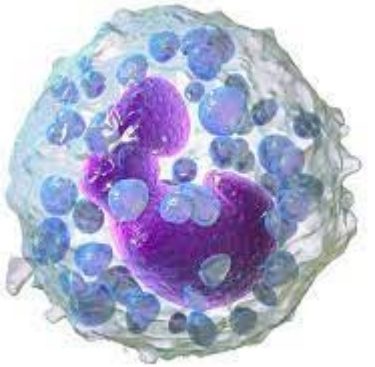
Basophil



Basophil

Number:	**<1% of total leucocytic count**
Size:	**10-12 µm in diameter**
L.M.:	**N:** irregular lobed and usually obscured by granules **C:** contains large dark basophilic granules The granules are **metachromatic** (stained purple with toluidine blue





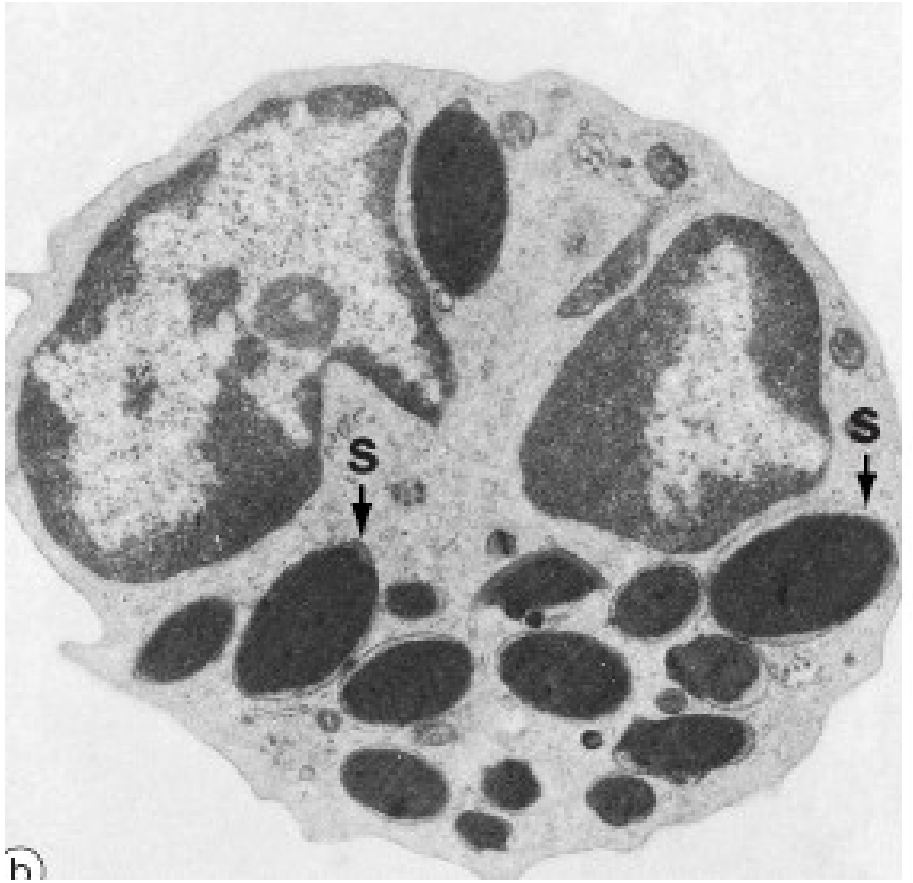
Due to the presence of heparin and other sulfated GAGs.

E.M.:

N: …

C: small rER, Golgi, few mitochondria

2 Types of granules:



1- 1ry Azurophilic granules:

- Primary lysosomes

2- Specific granules:

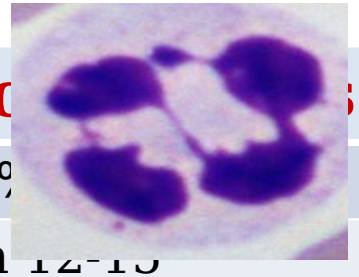
- **large / more irregularly shaped**
- **Contain heparin, histamin, leukotrienes and eosinophil chemotactic factor,**

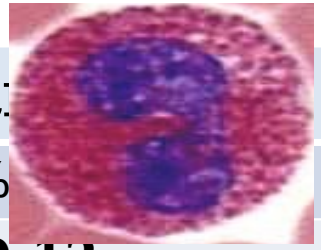
Functions:

- **Involved in allergic reaction…(receptors for Ig-E)**
- **Secrete their granular components in response to certain Ag/Ab reaction**

Allergy

Comparison between Granulocytes





Basophils	Eo[illegible]	Neut[illegible]	[illegible]
1%>	1-4%	60-70%	
µm 10-12	µm 12-15	**µm 10-12**	size
Irregular	**Bilobed**	**Segmented multilobed** ;2-5 dark lobes connected by delicate chromatin - **imm**ature **band neutrophil**. < 1-2%.	LM: nucleus
large dark basophilic gr. **metachromatic**	**large retractile acidophilic granules**	light neutral granules	Cytoplasm
small Golgi, **few** mitochondria **-Azurophilic: lysosomes** -Specific granules: **heparin, histamine, eosinophilic chemotactic factor**	small Golgi, **few** mitochondria **-Azurophilic: lysosomes** -Specific granules: electron dense crystalloid core internum **major basic proteins**, neurotoxin, peroxidase **Histaminase**	small Golgi , **few** mitochondria a-**Azurophilic granules: lysosomes** contain **hydrolytic** enz., b-**Specific** granules: **Small, numer**ous contain collagenase, c-Tertiary granules: gelatinase	EM

Agranulocytes

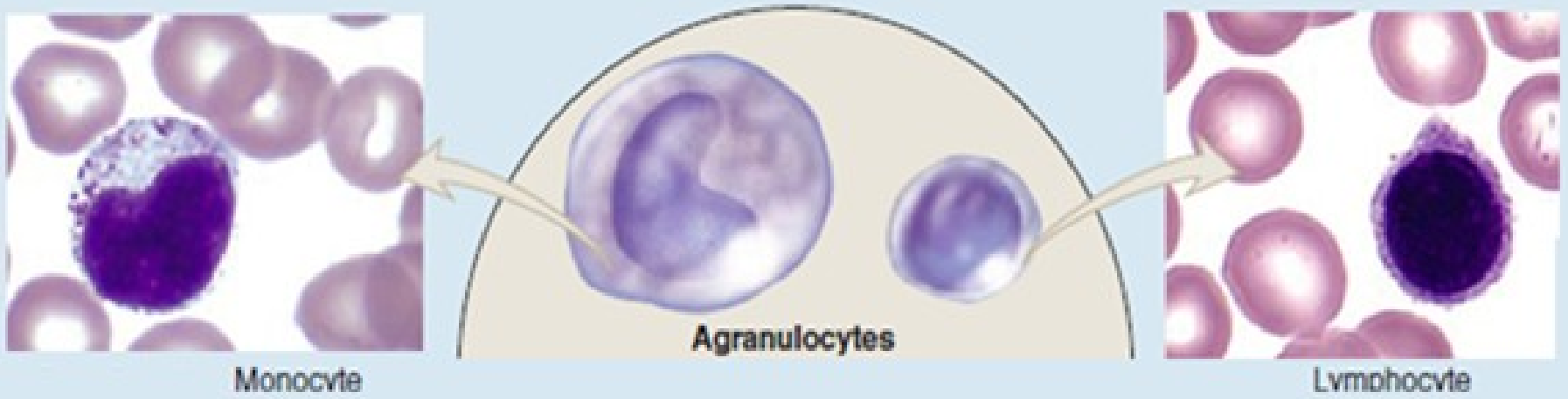
lack specific granules

But

contain azurophilic granules (lysosomes)

Monocytes

Lymphocytes



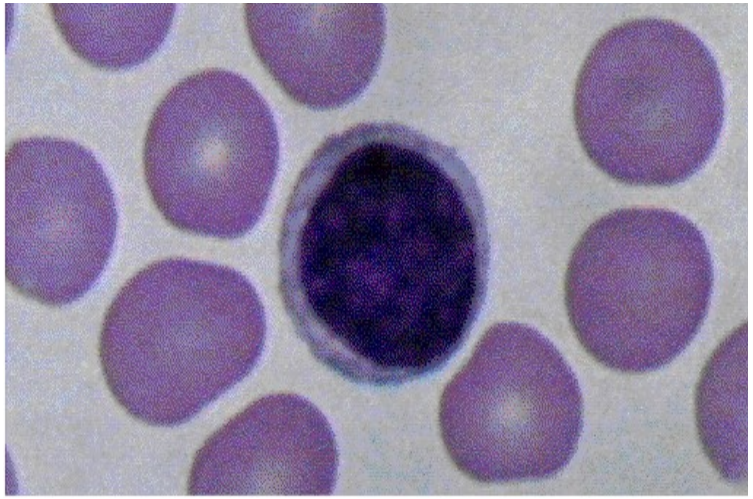
Lymphocytes

Number **20-25%** of total leucocytic count.

Size: divided according to size into:

a-Small lymphocytes: about **7 µm** in diameter, **most numerous**.

c- Large lymphocytes



Functionally divided into:

1-**B**-lymphocytes (B-cells) 15%,

2-**T**-lymphocytes (T-cells) 80%

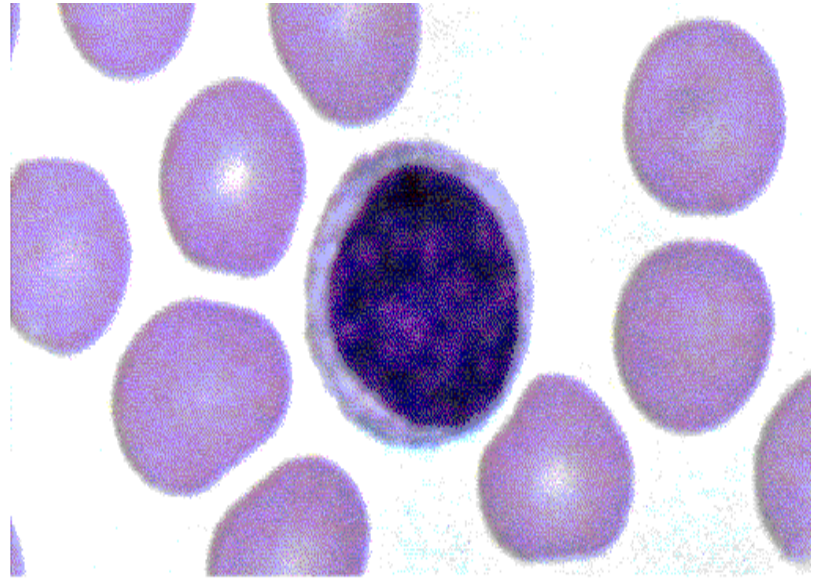
3- **Null** cells 5%

They have same morphology but can be differentiated by their **surface markers**

Small Lymphocytes

Size: **7 µm** in diameter

L.M.:



N: - **large** occupying most of the cell,
- **Rounded,** shows a slight indentation.
- **Dense.**

C: a **thin rim** around the nucleus.

light basophilic with little azurophilic granules.

Larger lymphocytes have:

- **Larger, slightly indented nuclei**
- **More cytoplasm that is slightly basophilic, with a few azurophilic gr.**

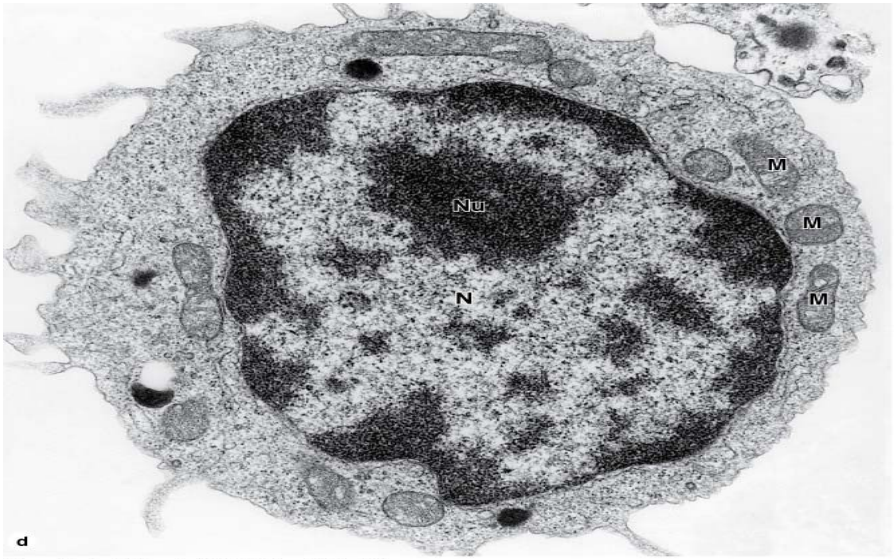
Lymphocytes

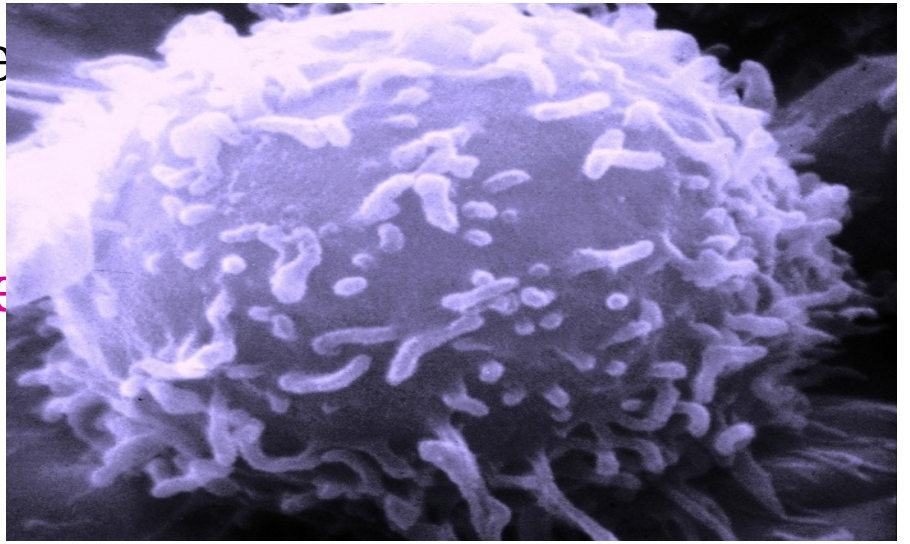
E.M.:

Nucleus: rich in heterochromatin

The Cytoplasm contains:

- Abundant **ribosomes**.
- Few mitochondria, small Golgi comple
  little rER.
- Few lysosomes (**azurophilic granule**

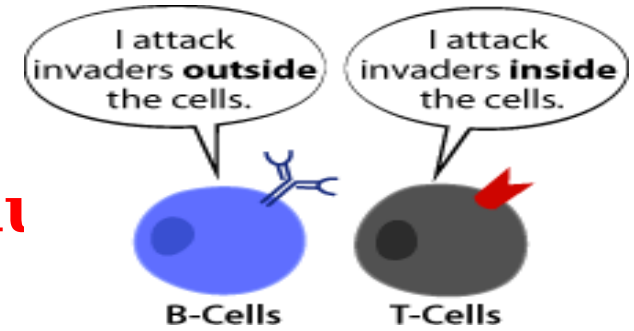




http://www.bloodjournal.org/content/104/5/1396?sso-checked=true

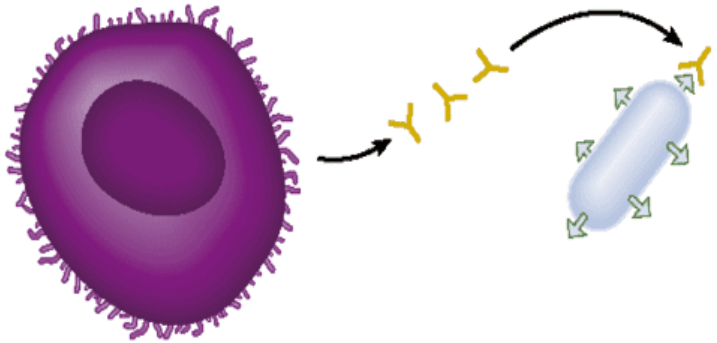
Functions:

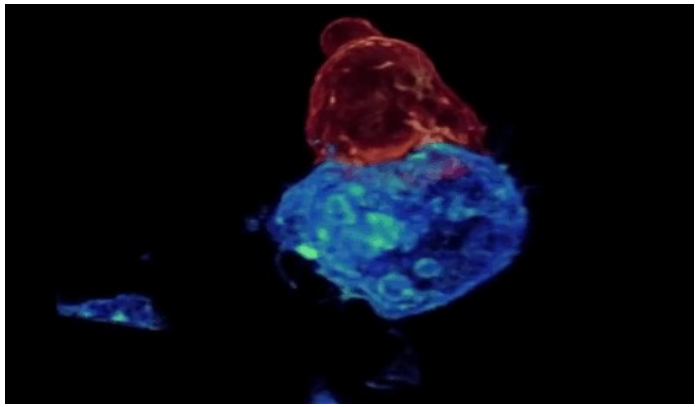
- In blood stream, No function
- In connective tissue, they play a role in immu



B-lymphocytes → Humoral

T-lymphocytes → Cytotoxic





https://sola.ai/i_t_r_on/t-lymphocyte-a-type-of-white-blood-cell-that-kills-cancer-1031553673

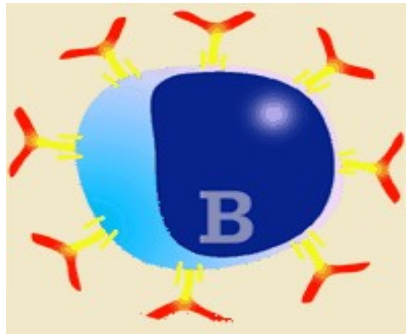
B-Lymphocyte function

Humoral-mediated immune response

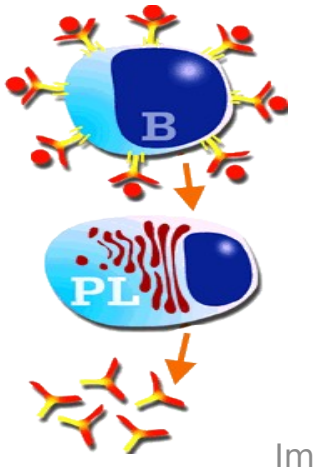
When B lymphocytes recognize an antigen, they proliferate and differentiate

1- Plasma cells:

secrete antibodies



http://apps.sanidadanimal.info/cursos/immunology-old/tercero2.htm



2-Memory cells:

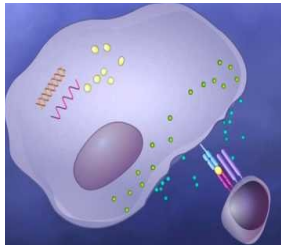
Re-exposure to same antigen

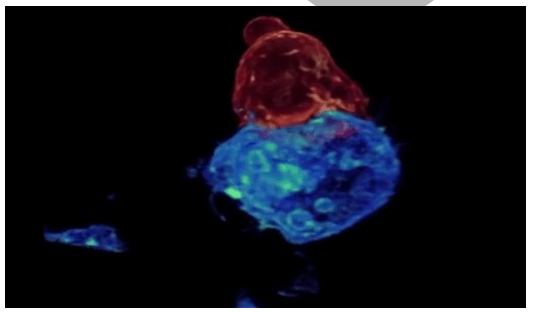
rapid and **more extensive** production of antibodies;

https://askabiologist.asu.edu/memory-b-cell

T-Lymphocyte functions

Cellular-mediated immune response





https://sola.ai/i_t_r_on/t-lymphocyte-a-type-of-white-blood-cell-that-kills-cancer-1031553673

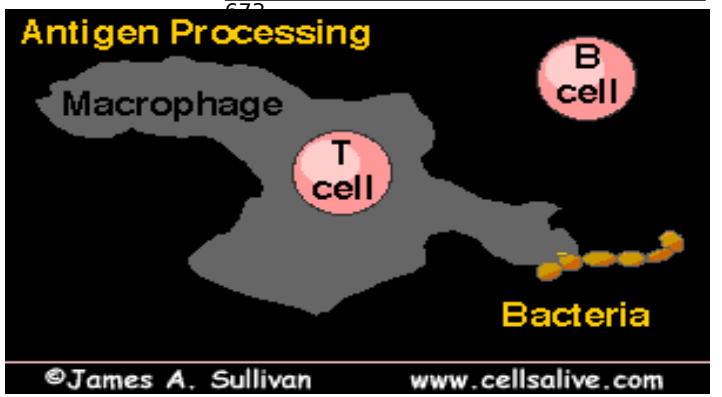
1- Cytotoxic T-lymphocytes:

they bind to the surface of foreign cells as viral infected cells & kill them

2-T-helper cells:

numerous factors → activation of B-lymphocytes

and cytotoxic T-lymphocytes.



http://leavingbio.net/human-defence-system/

3-T-suppressor cells:

modulate extent of immune response and suppress production of antibodies

4- T memory cells: long lived,

responsible for a more rapid and extensive secondary immune response.

Null Lymphocyte function

- **Natural killer cells (NK)** that can kill foreign cells; virally infected, tumor cells
- Secrete **interferon y.**

Lymphocyte Identification

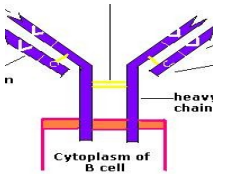
B and T lymphocytes are distinguished by detecting

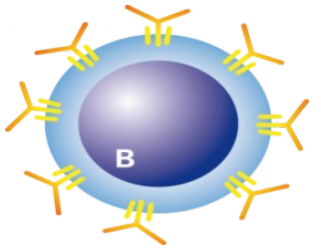
“surface markers“

using immunohistochemical methods

- **T-lymphocytes**: have T cell **receptors**,
  T- cell receptors
  CD molecules

- **B-lymphocytes**: have surface **immunoglobulins.**

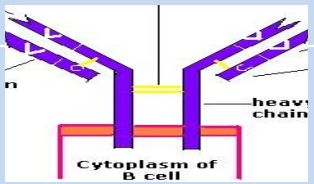


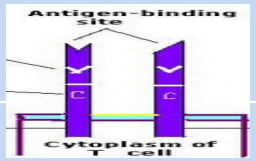


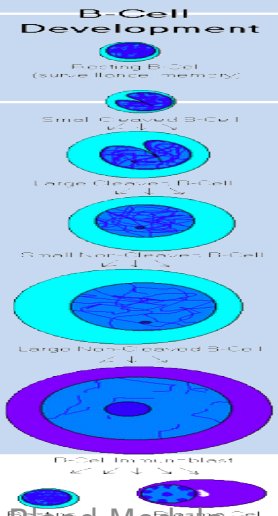
- **Null cells**: have no surface markers for T nor B lymphocytes.

Compare between B and T Lymphocytes

	B lymphocytes	T lymphocytes
Percent	**15%**	**80%**
Origin	Bone marrow	Bone marrow
Site of maturation	**Bone marrow**	**Thymus**
Surface markers	**Immunoglobulins**	**T-cell receptors** **Cluster of differentiation markers** (CD2, CD3, CD4,CD8, and CD28)
Life span	Few months	Many years
Function	**Humoral** immune response	**-Cell mediated** immune response (T cytotoxic) -T-helper -T-suppressor



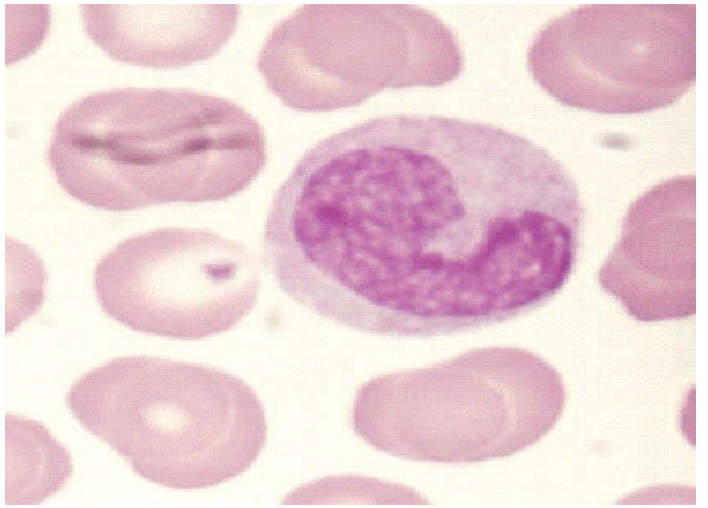




Monocytes

Number **3-8%** of total leucocytic count

Size: **12-20 µm**. (largest blood cell).

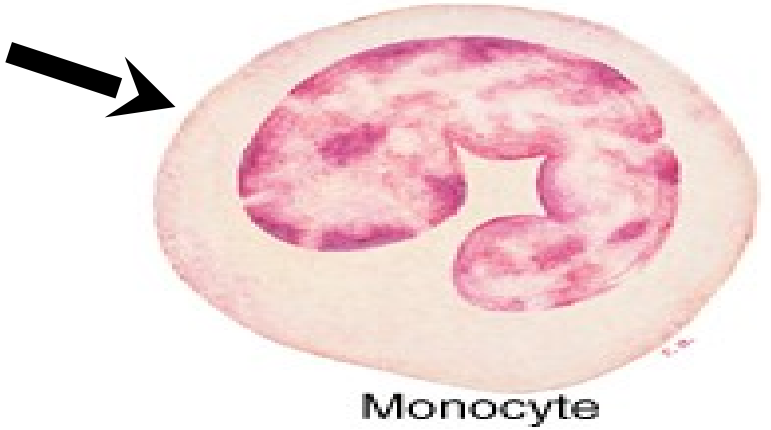


L.M.:

Nucleus:

-kidney-shaped, deeply indented or a wide horse-shoe shaped with 2 nucleoli.

- **Eccentric** in position.
- Less condensed



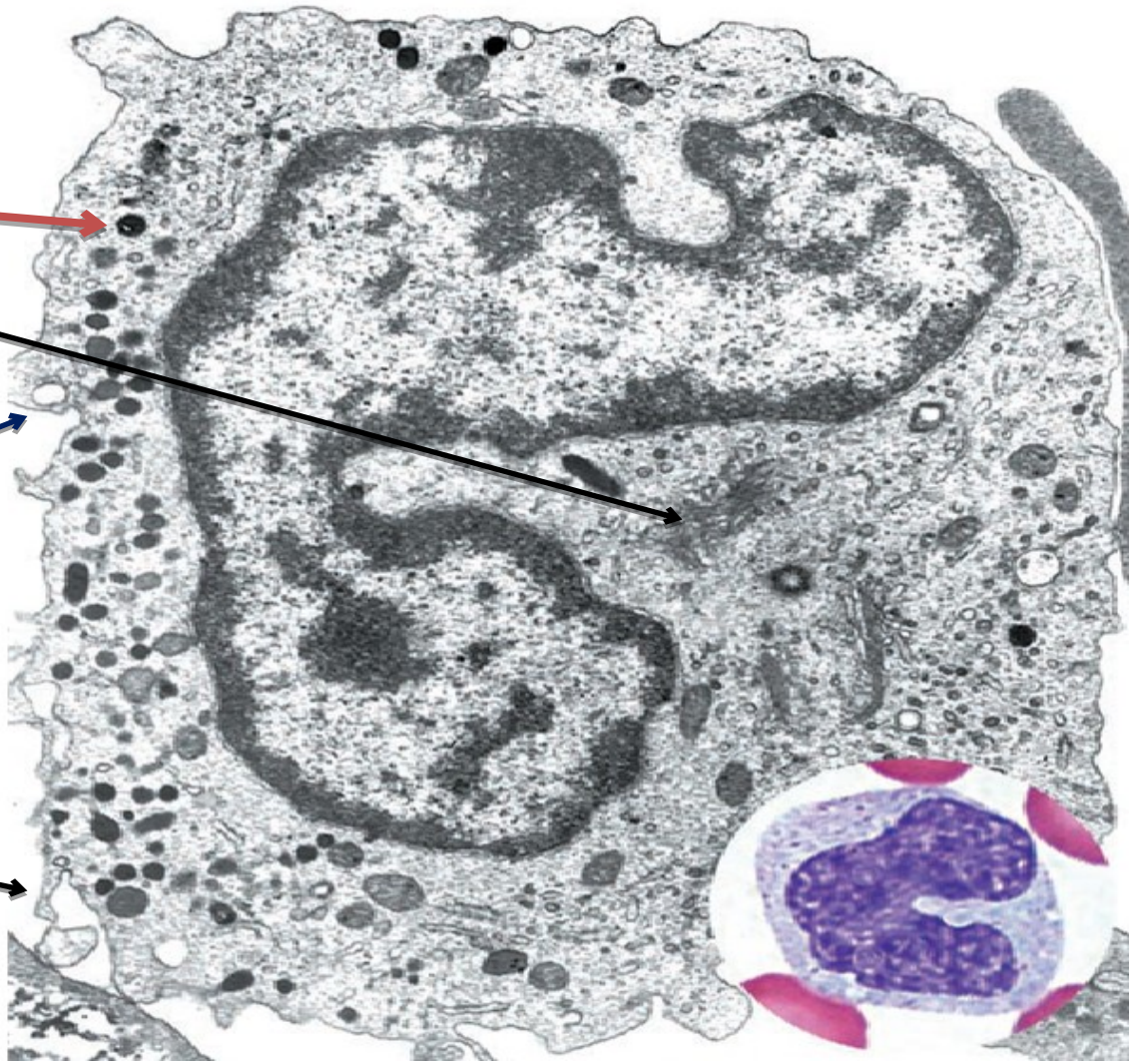
Cytoplasm:

abundant, pale with **fine pinkish-purple azurophilic granules.**

Monocytes

E.M.:

- **Numerous lysosomes**
- rER, prominent **Golgi complex** near the indentation of the kidney-shaped nucleus
- Mitochondria.
- **Pinocytotic vesicles**
- Irregular processes

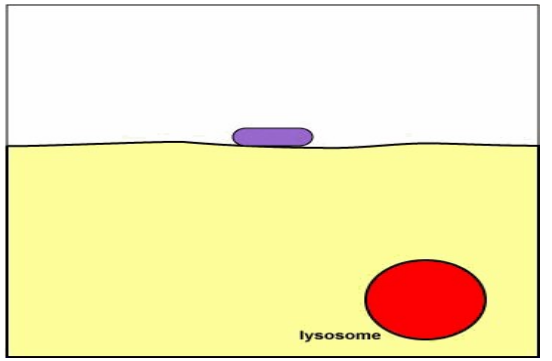


Monocyte Function

1- Phagocytosis:

Circulating monocytes can phagocytose bacteria and antigen antibody complexes in blood stream.

In the connective tissue they differentiate into macrophages.



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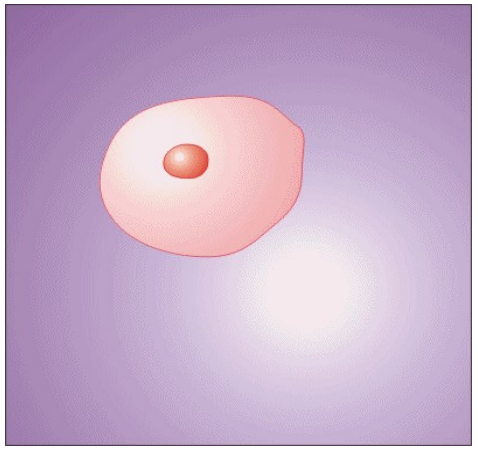
2- Antigen presenting:



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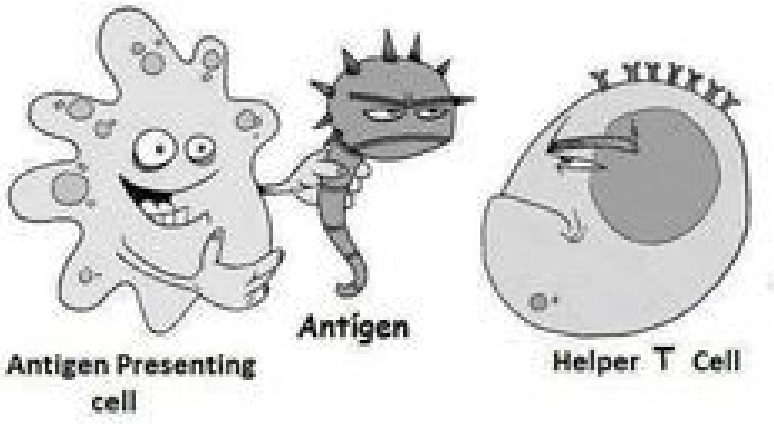

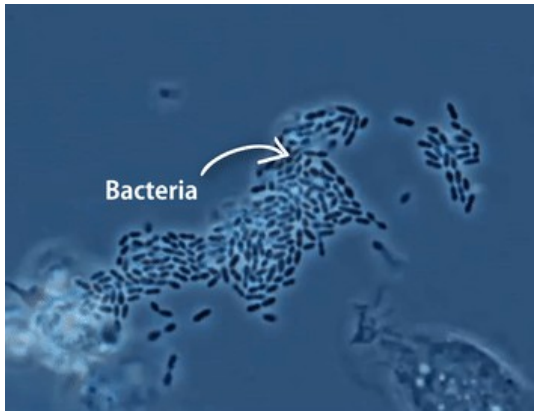

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Lecture Quiz

Lecture Quiz

The cells that increase in suppurative tonsilitis are characterized by

A-It is the largest leucocyte
B-Granules with electron dense core
C-Kidney shaped nucleus
D-Azurophilic granules

In acute inflammation, first line of defense includes

A-Eosinophils
B-Basophils
C-Neutrophils
D-Lymphocytes

Lecture Quiz

A 45 year old patient presented with hematuria and was diagnosed as bilharziasis. His blood shows an increase in a leukocyte whose granules are characterized by:

A-Secrete histamine
B-Stain metachromatically
C-Secrete collagenase
D-Have electron dense internum

Which of the following is an antigen presenting cell?

A- Basophils
B- Neutrophils
C- Monocytes
D- Esinophils

Lecture Quiz

tch the following cells with their contents

1- Neutrophils	a. Granules with electron dense core
2- Basophils	b. Granules containing collagenase
3- Esinophils	c. Secrete histamine
4- Monocytes	d. Numerous lysosomes

SUGGESTED TEXTBOOKS

1. **Junqueira`s Basic Histology; Text and Atlas. 14th edition 2016.**
2. **Histology atlas and test: Michael H. Ross and Wojciech Pawlina, 7th edition, 2015.**


Thank
you